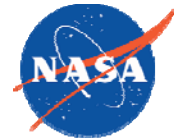


National Aeronautics and Space Administration



# Materials Science Research Rack Onboard the International Space Station

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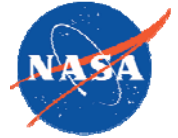
**November 2013**

[www.nasa.gov](http://www.nasa.gov)





# Materials Science Research Rack (MSRR)



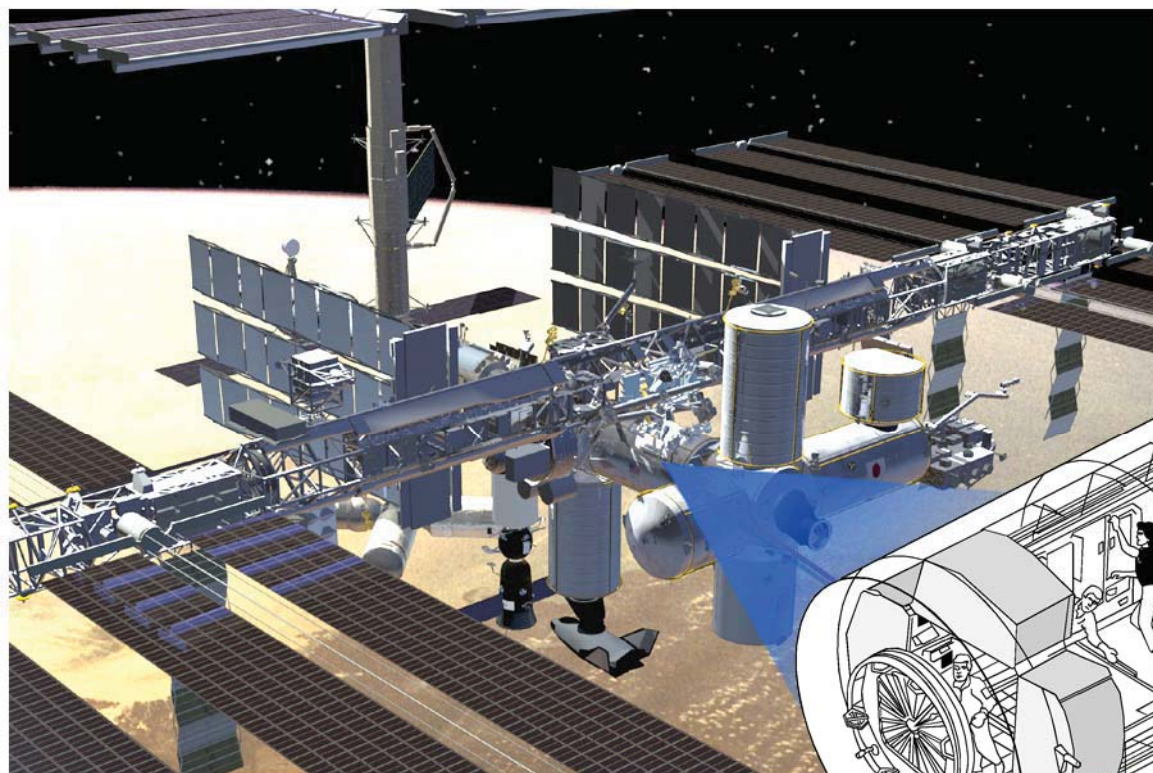
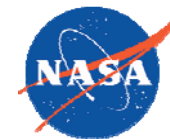
- ◆ **The Materials Science Research Rack (MSRR) is a highly automated facility developed in a joint venture/partnership between NASA and ESA**
  - Allows for the study of a variety of materials including metals, ceramics, semiconductor crystals, and glasses onboard the International Space Station (ISS)
  - Multi-user facility for high temperature materials science research
  - Launched on STS-128 in August 2009, and is currently installed in the U.S. Destiny Laboratory Module
- ◆ **Research goals**
  - Provide means of studying materials processing in space to develop a better understanding of the chemical and physical mechanisms involved
  - Benefit materials science research via the microgravity environment of space where the researcher can better isolate the effects of gravity during solidification on the properties of materials
  - Use the knowledge gained from experiments to make reliable predictions about conditions required on Earth to achieve improved materials



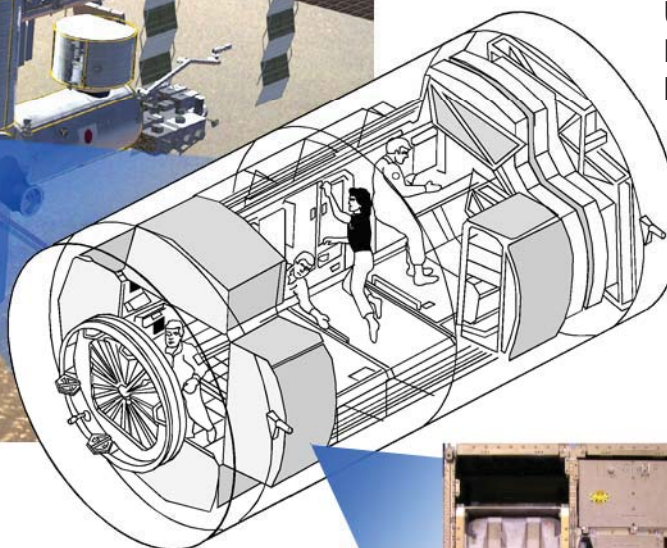




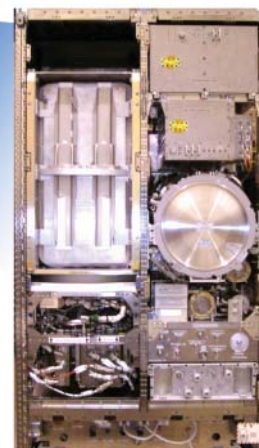
# MSRR Location



**International  
Space Station**



**U.S.  
Laboratory  
Module**

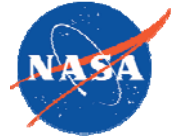


**Materials  
Science  
Research Rack**

- ◆ **MSRR is resident onboard ISS in the U.S. Destiny Laboratory Module in the Lab Overhead 3 position**



# Integrated Facility Overview



## ◆ NASA

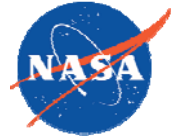
- MSRR Experiment Carrier (EC)
  - Boeing International Standard Payload Rack (ISPR) with Active Rack Isolation System (ARIS) capability
  - Rack Support System (RSS) – provides resource allocation to 2 Experiment Modules (Alpha and Beta sides of the rack) and provides access for the EMs to the ISS systems
    - Power
    - Data – 1553 BUS, Payload MDM
    - Video – provides signal and downlinks to ISS internal video system
    - Vacuum access – Vacuum Exhaust System and Vacuum Resource System
    - Thermal environment control - Moderate temperature cooling loop
    - MSRR Payload Laptop Computer
- Stowage – Experiment Module (EM) Alpha
  - On-orbit stowage for MSFC/ESA-provided tools, spares, Orbital Support Equipment, and Sample Cartridge Assemblies (SCAs)
  - Scarred with resources/services for additional an Experiment Module for future use

MSRR Flight Unit





# Integrated Facility Overview (continued)



## ♦ ESA

- Materials Science Laboratory (MSL) – Experiment Module Beta
  - Main mode of operation is directional solidification of alloys and semiconductors
  - Supports crystal growth by zone melting or measurement of diffusion coefficients (stationary temperature profiles)
  - Operation of resistance heated Furnace Inserts with up to 8 individually controlled heaters qualified for maximum temperatures of 1400 °C
  - Precise experiment control (temperature profiles and growth speed) with various experiment diagnostics and stimuli (e.g., rotating magnetic field to stir the liquid metal)
- Low Gradient Furnace (LGF)
  - Designed to achieve a well-controlled low or medium thermal gradient inside the sample between one high- and one low-temperature heater zones with an adiabatic zone in-between these 2 heater zones
- Solidification and Quenching Furnace (SQF)
  - Bridgman furnace designed to provide for high gradients typically in the range of 50 - 150 K/cm in the cartridge, consisting of one hot cavity, an exchangeable adiabatic zone, and a water cooled chill block (cooling zone) acting as heat sink
  - Quench capability provided by a rapid displacement of the furnace insert, typically 50 to 100 mm within about 1 second
- Sample Cartridge Assemblies (SCAs)
  - Leak-tight containers for materials samples, sensors for process control & safety, and stimuli
  - LGF-type SCAs and SQF-type SCA qualified for maximum temperatures of 940 °C and 1065 °C, respectively



LGF-Type SCA



LGF Flight Model



MSL Flight Model



SQF Flight Model



SQF-Type SCA





# Basic Operational Concept



- ◆ Furnace Inserts are exchangeable on-orbit
- ◆ SCAs are installed, one at a time, into the Furnace Insert by a Crew Member
- ◆ Experiments can be run by automated command via Sample Processing Programs (SPPs), telemetry commands from the ground, or by Crew Member commanding via the MSRR Laptop Computer
- ◆ Joint MSRR/MSL operations are performed via integrated team approach
  - MSRR operations team at the Huntsville Operations Support Center (HOSC) in Huntsville, AL
  - MSL operations team at the Microgravity User Support Center (MUSC) at DLR in Cologne, Germany
  - Principal Investigators (PIs) present in HOSC and MUSC control rooms during sample processing; PIs also receive near real-time data at the PI facilities
  - Ground labs available at MUSC and MSFC

HOSC Ground Control Room



MUSC Ground Control Room

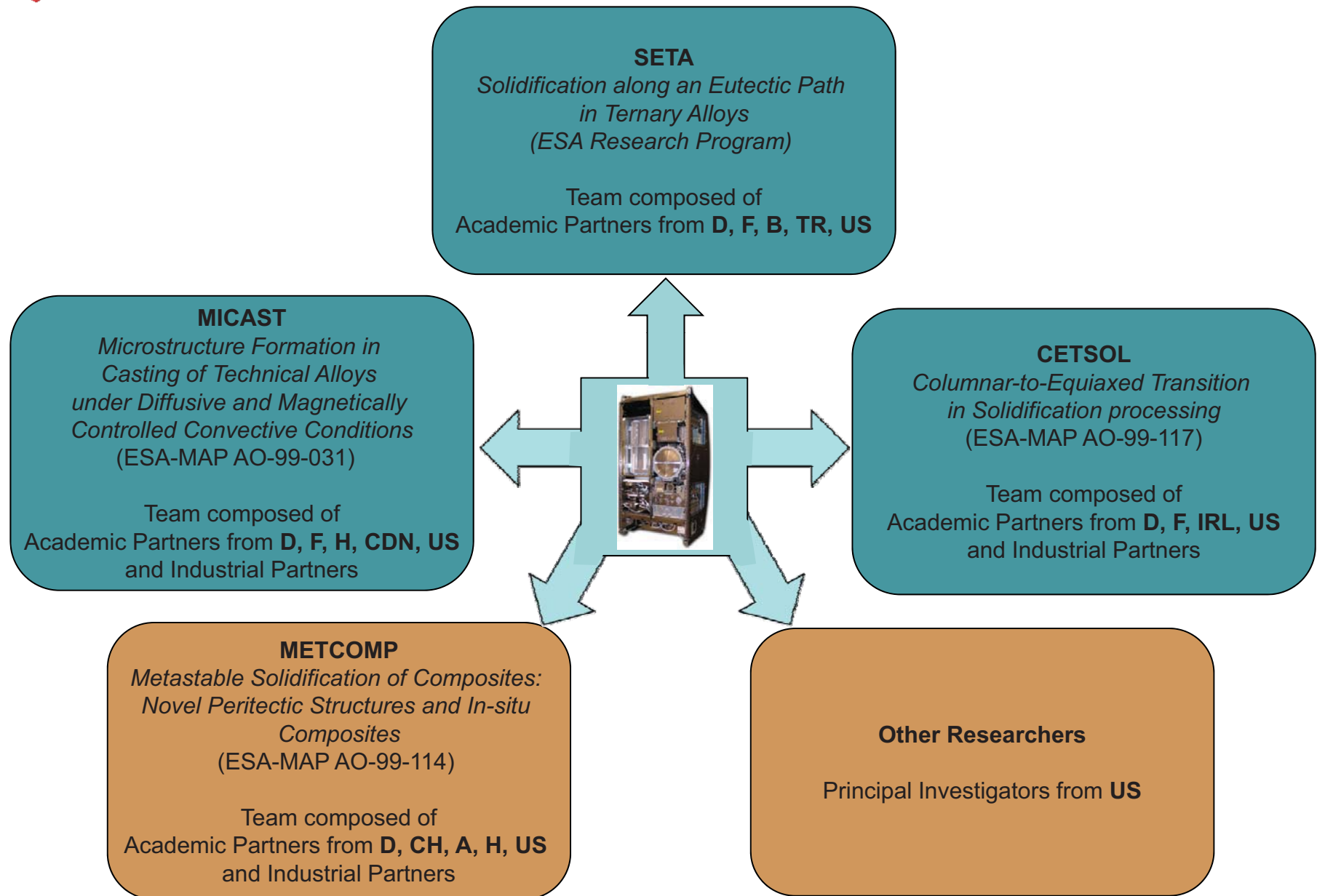
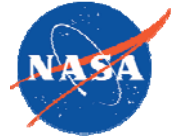
MUSC Ground Lab



MSFC Ground Lab including PRCU

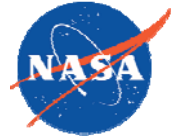


# Materials Science Research with MSRR/MSL

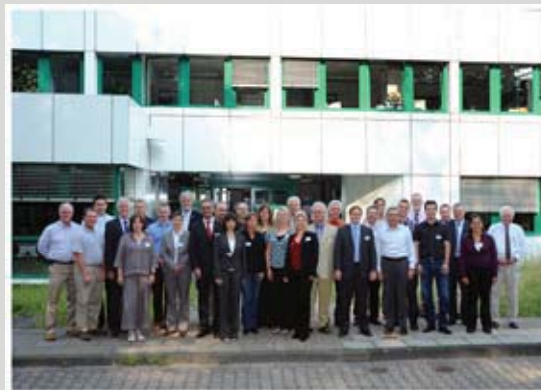




# MSRR/MSL Operations – Success Story



- ◆ MSRR/MSL have successfully completed over 1000 hours of operational time (as of September 2013)
- ◆ On-orbit commissioning was completed Nov 6, 2009
- ◆ 12 SCAs were successfully processed November 2009 – April 2010 in the LGF and downloaded on various Shuttle flights
- ◆ 8 SCAs were successfully processed January 2011 - September 2013 in the SQF and downloaded on various SpaceX flights
- ◆ Preliminary examination of samples indicate that the majority of the desired science objectives have been successfully met
- ◆ 10 SCAs are planned for processing in the coming months (as of September 2013)







# Future Plans



## ◆ Future SCAs provided by ESA

- Batch 2b SCAs planned for NET 2015
- Batch 3 SCAs planned NET 2018

## ◆ Future SCAs provided by NASA

- NASA SCA development kicked-off January 2011 to support US PIs and their partners
- The first of these Flight SCAs are being developed for investigations to support research in the areas of crystal growth and liquid phase sintering
- Subsequent investigations are in various stages of development
- NASA SCAs will be qualified for use in the LGF and SQF at maximum temperatures of 1250 °C
- US investigations will include a ground test program in order to distinguish the particular effects of the absence of gravity.
- First Flight SCAs planned for 2015, total of approximately 50 units by end of 2018

*This facility is available to support additional programs such as the US National Laboratory, Technology Development, NASA and International Research Announcements, ESA application-oriented research programs, and others.*

